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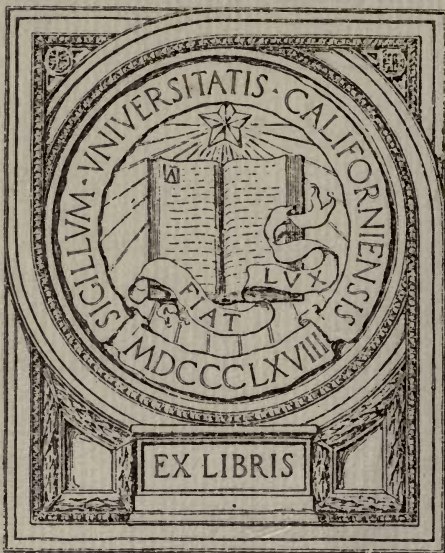
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M.O. 233.

METEOROLOGICAL OFFICE.

CLOUD FORMS

ACCORDING TO THE
INTERNATIONAL CLASSIFICATION.

The Definitions and Descriptions

APPROVED BY THE
INTERNATIONAL METEOROLOGICAL COMMITTEE
IN 1910.

WITH AN
ATLAS OF PHOTOGRAPHS OF CLOUDS

SELECTED FROM THE COLLECTION OF MR. G. A. CLARKE
OF THE OBSERVATORY, ABERDEEN.

Issued by the Authority of the Meteorological Committee.

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ATLAS OF CLOUD FORMS.

- PLATE I. Type 1.—Stratus (St.). Level sheet of low cloud below 3,000 feet.
- PLATE II. Type 61.—Fracto-stratus (Fr. St.). Ragged Stratus. Drifting masses of low cloud.
- PLATE III. Type 2.—Nimbus (Nb.). Shapeless cloud with ragged lower edge and rain falling (base below 7,000 feet).
- PLATE IV. Type 3.—Cumulus (Cu.). Detached cloud with flat base (mean height 4,500 feet) and rounded top (mean height 6,000 feet).
- PLATE V. Type 63.—Fracto-cumulus (Fr. Cu.). Ragged cumulus in drifting masses, 4,000 feet—6,000 feet.
- PLATE VI. Type 32.—Cumulo-nimbus (Cu. Nb.). Mountainous mass (reaching sometimes from 5,000 feet to 25,000 feet).
- PLATE VII. Type 32 with 84. Cumulo-nimbus (Cu. Nb.). Thunder cloud with large "anvil" of false cirrus.
- PLATE VIII. Type 32 with 84.—Cumulo-nimbus (Cu. Nb.). Shower cloud ; top fringed with false cirrus.
- PLATE IX. Type 82.—Mammato-cumulus (M. Cu.). The last stage of cumulo-nimbus.
- PLATE X. Type 13.—Strato-cumulus (St. Cu.). Layer of lumpy clouds below 7,000 feet.
- PLATE XI. Type 51.—Alto-stratus (A. St.). Level sheet at middle height 10,000 to 23,000 feet.
- PLATE XII. Type 53.—Alto-cumulus (A. Cu.). Layer of large cloudlets in rows or waves at middle height.
- PLATE XIII. Type 93.—Cirro-cumulus (Ci. Cu.). Higher than *alto-cumulus*. Mackerel sky ; layer of small cloudlets in waves.
- PLATE XIV. Type 73.—Alto-cumulus-lenticularis (A. Cu. lent.). Almond-shaped banks of cloudlets at *alto-cumulus* level.
- PLATE XV. Type 73.—Cirro-cumulus-lenticularis (Ci. Cu. lent.). Almond-shaped banks of cloudlets at *cirro-cumulus* level.
- PLATE XVI. Type 94.—Cirrus (Ci.). Mares tails with tufted ends (Cirrus uncinus) (often at about 30,000 feet).
- PLATE XVII. Type 91.—Cirro-stratus (Ci. St.). Uniform sheet of very high cloud (30,000 feet), line of ragged cumulus about 25,000 feet below.

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METEOROLOGICAL OFFICE.

CLOUD FORMS

ACCORDING TO THE INTERNATIONAL CLASSIFICATION.

The Definitions and Descriptions approved by the International Meteorological Committee in 1910, with an Atlas of Photographs of Clouds selected from the Collection of Mr. G. A. Clarke, of the Observatory, Aberdeen.

The international classification of cloud-forms is based upon the four fundamental types of the classification proposed by Luke Howard at the beginning of the 19th Century, namely, *cirrus*, the thread-cloud; *cumulus*, the heap-cloud; *stratus*, the flat cloud or level sheet; and *nimbus*, the rain-cloud. The details of a more precise classification occupied the attention of meteorologists in many countries during the latter part of the century, among whom were specially prominent our own countrymen, the Rev. Clement Ley and the Hon. Ralph Abercromby. A book by Mr. Clement Ley entitled "Cloudland" is well known to meteorologists. Mr. Abercromby contributed a number of papers on the subject, laying stress upon the most important fact that cloud-forms are not peculiar to special localities or latitudes, but are the same for all parts of the world. Both these gentlemen unfortunately died before the classification was settled. The other meteorologists who were specially active in this work were Professor H. H. Hildebrandsson, of Upsala, Sweden; M. Léon Teisserenc de Bort, of Paris; and M. A. Riggenbach, of Zurich, Switzerland.

In 1891 the International Conference at Munich recommended the following classification of clouds elaborated by Messrs. Abercromby and Hildebrandsson:—

- (a) Detached clouds with rounded upper outlines (most frequent in dry weather).
- (b) Clouds of great horizontal extent suggesting a layer or sheet (suggestion of wet weather)

A.—Upper Clouds: average altitude, 9,000 metres (30,000 feet).

- (a) 1. *Cirrus*.
- (b) 2. *Cirro-stratus*.

B.—Intermediate Clouds: between 3,000 metres and 7,000 metres (10,000 feet and 23,000 feet).

- (a) { 3. *Cirro-cumulus*.
- 4. *Alto-cumulus*.
- (b) 5. *Alto-stratus*.

C.—Lower Clouds: below 2,000 metres (7,000 feet).

- (a) 6. *Strato-cumulus*.
- (b) 7. *Nimbus*.

D.—Clouds of diurnal ascending currents.

(a) 8. Cumulus: top, 1800 metres (6,000 feet); base, 1,400 metres (4,500 feet).

(b) 9. Cumulo-nimbus: top, 3,000 metres to 8,000 metres (10,000 feet to 26,000 feet); base, 1,400 metres (4,500 feet).

E.—High Fogs under 1,000 metres (3,300 feet).

10. Stratus.

N.B.—The equivalents in feet of the heights given in metres are only roughly approximate.

After Abercromby's death, at the request of the International Meteorological Committee in 1894 a Cloud Atlas was prepared by Messrs. Hildebrandsson, Riggenbach and Teisserenc de Bort and published in 1895, with excellent illustrations in photochromotype executed at Zürich. It was naturally very acceptable to meteorologists in all countries, and the number of copies was soon exhausted. In 1905 the International Meteorological Conference at Innsbruck requested Messrs. Hildebrandsson and Teisserenc de Bort to prepare a new edition, making at the same time some suggestions for the improvement of the classification and definitions. Among these suggestions the following should be noted because it indicates a special type of cloud. "Certain cloud forms which are particularly frequent on days of sirocco, mistral or föhn, have an oval shape and occasionally show irisation. These cloud forms are to be described by the term *lenticularis*, *e.g.*, *cumulus lenticularis* (cu. lent.), *stratus lenticularis* (st. lent.). A plate illustrating this cloud form should be included in the Cloud Atlas."

These lenticular, lentil-shaped or almond-shaped clouds have attracted some attention in recent times. They have a peculiar outline. In many cases they are very suggestive of an airship, and are perhaps the clouds in "Hamlet" which are "very like a whale" (Plate XIV). In others the inner part of the cloud becomes very thin, or disappears, so that the shape looks like a large horse-shoe as seen from beneath at a great distance (Plate XV). Photographs of typical specimens have been secured by Mr. G. A. Clarke at Aberdeen, and by Captain Cave at Ditcham Park. At the Meteorological Office there is a very fine specimen of a stereophotograph, with a wide base, of one of horse-shoe-shape, which shows admirably the detail of the structure of curled wisps which form the cloud. The photographs and eye-observations show that the bank of clouds which keeps its position with little apparent change is really composed of a mass of cloudlets, forming and drifting into the cloud-bank with the wind at one side drifting away from it and dissolving at the other. Thus the stationary appearance of the cloud-bank is illusory as regards the wind. The wind blows *through* the cloud-bank, which is formed by the massing of the drifting cloudlets. The cloudlets belong apparently to the type of alto-cumulus or cirro-cumulus, not to the massed clouds, stratus or cumulus, as suggested by the Conference. The example inserted in the new edition of the Cloud Atlas is cirro-cumulus-lenticularis. The relation of this cloud to *sirocco*, which is a southerly wind in front of an advancing depression of the Mediterranean Sea, or to the *föhn*, which is the continuation of the same

wind on the northern side of the Alps, or to the *mistral*, which is a dry wind from the North-West on the French Mediterranean coast, has not been investigated.

Upon two examples of this type of cloud Mr. Clarke remarks as follows: "Very often the intermediate clouds of the cirro-cumulus, alto-cumulus and strato-cumulus types may be seen massed together in long oval or torpedo-shaped sheets. These are termed *Lenticular* clouds, from the resemblance of their form to that of the cross-section of a lens. These *lenticular* masses are found sometimes detached but at other times cover the sky in dense sheets at several different levels, and are generally seen when the wind is blowing from some point in the south-west quadrant. The following conditions are found to accompany their appearance:—(1) The sky, when visible, is usually of a very intense blue colour; (2) the barometer is exceedingly unsteady, rising and falling jerkily at very short intervals of time; (3) the wind is usually strong or high and of a very gusty character, and in addition there is a periodic rise and fall in its average velocity. At times the lower clouds, such as *Cumulus* and *Stratus* are seen to assume a somewhat similar form in *quiet* weather, but in such cases the conditions above-mentioned will be absent."

That clouds similar to those associated with mistral or föhn are to be found in south-westerly winds at Aberdeen, where there are mountains to the south-westward, and over the South Downs at Ditcham Park, points perhaps to the orographical influence of the land surface upon the currents of the upper air, and it seems desirable to have a definite class to which such clouds can be referred.

The new edition of the Cloud Atlas was issued in 1910, and the definitions and descriptions of cloud forms are as follows:—

[The translation into English has been altered in certain respects from that which appears in the English version of the introduction to the International Cloud Atlas, in order to represent more closely the original French.]

INTERNATIONAL DEFINITIONS AND DESCRIPTIONS OF CLOUD-FORMS.

1. *Cirrus (Ci).—Detached clouds of delicate appearance, fibrous (threadlike) structure and feather-like form, generally white in colour. Cirrus clouds take the most varied shapes, such as isolated tufts of hair, *i.e.*, thin filaments on a blue sky, branched filaments in feathery form, straight or curved filaments ending in tufts (called cirrus uncinus), and others. Occasionally cirrus clouds are arranged in bands, which traverse part of the sky as arcs of great circles, and as an effect of perspective appear to converge at a point on the horizon, and at the opposite point also if they are sufficiently extended. Cirro-stratus and cirro-cumulus also are sometimes similarly arranged in long bands. Plate XVI.

* It may be noted that the outline of the sun is visible, and his rays cast a shadow in spite of the presence of clouds of this type, unless the clouds and the sun are both low down on the horizon.

2. *Cirro-Stratus (Ci.-St.).—A thin sheet of whitish-cloud ; sometimes covering the sky completely and merely giving it a milky appearance ; it is then called cirro-nebula or cirrus haze ; at other times presenting more or less distinctly a fibrous structure like a tangled web. This sheet often produces halos around the sun or moon. Plate XVII.

3. *Cirro-Cumulus (Ci.-Cu.) (Mackerel Sky).—Small rounded masses or white flakes without shadows, or showing very slight shadow : arranged in groups and often in lines. French, *Moutons*—German, *Schäfchen-wolken*. Plate XIII.

4. Alto-Stratus (A.-St.).—A dense sheet of a grey or bluish colour, sometimes forming a compact mass of dull grey colour and fibrous structure. At other times the sheet is thin like the denser forms cirro-stratus, and through it the sun and the moon may be seen dimly gleaming as through ground glass. This form exhibits all stages of transition between alto-stratus and cirro-stratus, but according to the measurements its normal altitude is about one-half of that of cirro-stratus. Plate XI.

5. Alto-Cumulus (A.-Cu.).—Larger rounded masses, white or greyish, partially shaded, arranged in groups or lines, and often so crowded together in the middle region that the cloudlets join. The separate masses are generally larger and more compact (resembling strato-cumulus) in the middle region of the group, but the denseness of the layer varies and sometimes is so attenuated that the individual masses assume the appearance of sheets or thin flakes of considerable extent with hardly any shading. At the margin of the group they form smaller cloudlets resembling those of cirro-cumulus. The cloudlets often group themselves in parallel lines, arranged in one or more directions. Plate XII.

6. Strato-Cumulus (St.-Cu.).—Large lumpy masses or rolls of dull grey cloud, frequently covering the whole sky, especially in winter. Generally strato-cumulus presents the appearance of a grey layer broken up into irregular masses and having on the margin smaller masses grouped in flocks like alto-cumulus. Sometimes this cloud-form has the characteristic appearance of great rolls of cloud arranged in parallel lines close together. (Roll-cumulus in England, Wulst-cumulus in Germany.) The rolls themselves are dense and dark, but in the intervening spaces the cloud is much lighter and blue sky may sometimes be seen through them. Strato-cumulus may be distinguished from Nimbus by its lumpy or rolling appearance, and by the fact that it does not generally tend to bring rain. Plate X.

7. Nimbus (Nb.).—A dense layer of dark, shapeless cloud with ragged edges from which steady rain or snow usually falls. If there are openings in the cloud an upper layer of cirro-stratus or alto-stratus may almost invariably be seen through them. If a layer of nimbus separates in strong wind into ragged cloud, or if small detached clouds are seen drifting underneath a large nimbus (the "Scud" of sailors), either may be specified as fracto-nimbus (Fr.-Nb.). Plate III.

* It may be noted that the outline of the sun is visible, and his rays cast a shadow in spite of the presence of clouds of these types, unless the clouds and the sun are both low down on the horizon.

8. **Cumulus (Cu.)** (Woolpack or Cauliflower Cloud).—Thick cloud of which the upper surface is dome-shaped and exhibits protuberances while the base is generally horizontal. These clouds appear to be formed by ascensional movement of air in the daytime which is almost always observable. When the cloud and the sun are on opposite sides of the observer, the surfaces facing the observer are more brilliant than the margins of the protuberances. When on the contrary, it is on the same side of the observer as the sun it appears dark with bright edges. When the light falls sideways, as is usually the case, cumulus clouds show deep shadows. Plate IV.

True cumulus has well-defined upper and lower margins ; but one may sometimes see ragged clouds—like cumulus torn by strong wind—of which the detached portions are continually changing ; to this form of cloud the name **Fracto-Cumulus** may be given. Plates V and XVII.

9. **Cumulo-Nimbus (Cu.-Nb.)** the Thunder Cloud ; Shower Cloud.—Great masses of cloud rising in the form of mountains or towers or anvils, generally having a veil or screen of fibrous texture (false cirrus) at the top and at its base a cloud-mass similar to nimbus. From the base local showers of rain or of snow, occasionally of hail or soft hail, usually fall. Sometimes the upper margins have the compact shape of cumulus or form massive heaps round which floats delicate false cirrus. At other times the margins themselves are fringed with filaments similar to cirrus clouds. This last form is particularly common with spring showers. The front of a thunderstorm of wide extent is frequently in the form of a large low arch above a region of uniformly lighter sky. Plates VI, VII and VIII.

10. **Stratus (St.)**—A uniform layer of cloud like fog but not lying on the ground. Plate I. The cloud layer of stratus is always very low. If it is divided into ragged masses in a wind or by mountain tops, it may be called **Fracto-Stratus**. Plate II. The complete absence of detail of structure differentiates stratus from other aggregated forms of cloud.

The following remarks are added in the international atlas as instructions to observers.

(a) In the daytime in summer all the lower clouds assume, as a rule, special forms more or less resembling cumulus. In such cases the observer may enter in his notes "**Stratus-** or **nimbus-cumuliformis.**"

(b) Sometimes a cloud will show a mammillated surface and the appearance should be noted under the name **mammato-cumulus**. Plate IX.

(c) The form taken by certain clouds particularly on days of sirocco, mistral, föhn, etc., which show an ovoid form with clean outlines and sometimes irisation, will be indicated by the name **lenticular**, for example : **cumulus lenticularis**, **stratus lenticularis** (Cu.-lent., St.-lent.).

(d) Notice should always be taken when the clouds seem motionless or if they move with very great velocity.

The illustrations in colour in the Cloud Atlas, twenty-nine in all, comprised

Four examples of cirrus,	Two of cumulus,
One of cirro-stratus,	One of fracto-cumulus,
One of cirro-cumulus,	Four of cumulo-nimbus,
Two of alto-stratus,	One of mammato-cumulus,
Two of alto-cumulus,	One of stratus,
Two of strato-cumulus,	One of fracto-stratus,
Three of nimbus,	One of cirro-cumulus-lenticularis,
One of fracto-nimbus,	One additional alto-cumulus,
One of tufted cirrus.	

The Atlas is now unfortunately again out of print, and, in consequence of the war, it is not likely that a reprint can be obtained. In order to meet immediate requirements, a number of photographs have been selected from Mr. G. A. Clarke's collection and are reproduced here as a provisional atlas of cloud-forms.

It includes two specimens of lenticular cloud banks, one at the alto-cumulus-level and the other at the cirro-cumulus-level. Plates XIV and XV. A definition of this peculiar form of cloud is necessary. It may be put into the following words.

11. Lenticular Cloud Banks.—Banks of cloud of an almond or air-ship shape, with sharp general outlines, but showing, on close examination, fretted edges, formed of an ordered structure of cloudlets similar to alto-cumulus or cirro-cumulus which is also seen in the bank itself when the illumination is favourable. Sometimes the body of the cloud bank is dense, and the almond shape is complete, fore and aft, but sometimes the bank thins away from the forward edge to clear sky within, so that the bank presents the appearance of a horse-shoe seen in perspective from below at a great distance. The bank appears nearly or quite stationary, while the cloudlets move rapidly into it at one side and away from it at the other.

Although we have at present no illustrative plate we may add a description of a form of cloud to which Clement Ley gave a separate name.

12. Alto-Cumulus-Castellatus.—“Little miniature cumulus rising in many heads from a more or less compact layer of alto-cumulus.” “Not a very common cloud in these latitudes but sometimes seen in Summer, and when coming from a westerly or south-westerly point is almost always a sign of the approach of shallow depressions which bring thunderstorms.”

Captain C. J. P. Cave, R.E. The Form of Clouds. *Q. J. Roy. Met. Soc.* Vol. XLIII, p. 68. 1917.

CLOUD TYPES.

In making a cloud Atlas it has always been customary to begin with the highest clouds, viz., *cirrus* and *cirro-stratus*, and gradually to let our view descend to the surface, where we find the only form of cloud actually known to many of us by practical experience of its interior, namely, fog or mountain-stratus. The learner or inexperienced reader may find it easier to proceed the other way, and starting from the fog, with which he is familiar, pass to the consideration of stratus, and nimbus, with which he has also a

working acquaintance, to cumulus, which is the first cloud to prompt an answer to the question of its origin and development, and so on to the cloud forms—some ordered, some irregular—of the upper regions of the air, about the formation and structure of which we know little.

It should be noticed in this connexion, that the problem presented to those who classify clouds is of a dual character. There are first the forms of individual clouds, *stratus*, *nimbus*, *cumulus*, and *cirrus*, while the other forms are really aggregates, or groups of clouds or cloudlets, arranged sometimes in a continuous mass, sometimes in rows or waves, not infrequently in double or even triple sets of waves. There are all sorts of gradations, from the dappled mackerel sky of *cirro-cumulus* to the *alto-cumulus*, with a dense central portion and separate clouds on the margins, the irregular masses of *strato-cumulus*, and finally the continuous *stratus* which is to be found at various different levels—low, intermediate, and high. We can hardly exclude the continuous *stratus* itself from consideration as a group or aggregate, because when it thins it breaks up into detached clouds.

I have arranged the photographs according to these ideas, and in numbering the types I have adopted the following scheme of enumeration:—

TYPES OF SINGLE-CLOUD-FORMS.

The figure 1 means	stratus
„ „ 2 „	nimbus
„ „ 3 „	cumulus
„ „ 4 „	cirrus

TYPES OF CLOUD GROUPS.

The figure 5 means	clouds in ordered groups of middle height between 7,000 feet and 25,000 feet.
„ „ 6 „	ragged clouds drifting in detached masses or irregular groups.
„ „ 7 „	lenticular groups; almond-shaped or horseshoe-shaped banks of cloudlets, generally between 10,000 feet and 25,000 feet.

OTHER TYPES.

The figure 8 means	portions of a cloud-mass having a peculiar structure
„ „ 9 „	the highest forms of clouds.

The combination of two figures gives the appropriate number for the types which appear in the international classification, and are illustrated in the Atlas.

A word must be added about *cirrus*. It is generally understood to be not only a cloud of thread-like structure, as its name implies, but at the same time a very high-cloud, its normal height being about 9 kilometres, or nearly 30,000 feet. No doubt the best and most durable examples are to be found at those great heights, but

from personal observation and from the consideration of many observations by Mr. Clarke, I think it must be allowed that thread-like clouds, indistinguishable in appearance from wisps of true cirrus, may be found at much lower levels just as the so-called false cirrus is formed at various heights. Captain C. K. M. Douglas, from close observation in an aeroplane, expresses the opinion that false cirrus, or, in other words, thread-like structure, is always attributable to clouds formed of ice crystals, and if that be the properly distinctive characteristic of the thread-like structure, it only hampers our conception of the atmospheric processes if we assume all clouds which show that structure to be at a very high level. The form is really suggestive of the formation of cloud by some special physical process, such as the reduction of the pressure of a mass of air which contains exceptional quantity of water vapour in streaks or wreaths. It is better, therefore, to regard cirrus as being a special form of cloud which may be developed in suitable circumstances at any level where ice crystals can form, and where a reduction of pressure, in consequence of external changes, may occur; this may be any region beyond the four-kilometre level in our latitude. Consequently, I give a separate number 4 to cirrus as a cloud of thread-like structure, and another number 9 to the highest clouds, so that the clouds that we are accustomed to call "true cirrus"—that is, thread-like clouds in the region of 9 kilometres height—are designated by the composite number 94.

The information given here is concerned almost entirely with the identification of cloud forms which is only the first step in the meteorological study of clouds. It should be noted that in the year 1896-97, known among meteorologists as the international cloud-year, observations were made on an international basis of the height and the velocity of motion of all the typical forms of cloud at the following observatories:—Bossekop (Norway), Upsala (Sweden), Pavlovsk near Petrograd (Russia), Potsdam (Germany), Trappes near Paris (France), Toronto (Canada), Blue Hill near Boston and Washington D.C. (U.S.A.), Allahabad (India), and Manilla (Philippine Islands). A very instructive summary of these and other observations of clouds is given in Chapters IV and VII of *Les bases de la météorologie dynamique* par H. H. Hildebrandsson et Léon Teisserenc de Bort. According to the discussion of the heights of clouds at Potsdam, clouds tend to favour the following levels (the heights are in metres) 500, 2,000, 4,300, 6,500, 8,300, 9,900. These heights are, however, only general means. They vary from one station to another and are also subject to diurnal and seasonal variations.

NAPIER SHAW.

Meteorological Office, London,

May, 1918.

2. Reports of Investigations in Meteorology and Geophysics.

(M) Geophysical Memoirs (4to.):

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